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ABSTRACT

Presented is a project that developed a competency-based clinical chemistry course for associate degree medical laboratory technicians (MLT) in a medical technology (MT) baccalaureate program. Content of the course was based upon competencies expected of medical technologists at career-entry as defined in the statements adopted in 1976 by the House of Delegates of the American Society for Medical Technology. The course was designed to enable medical laboratory technicians who have developed some, but not all, of the required skills of a medical technologist to augment their knowledge and proficiency in specific units of study rather than complete the entire course. Following an introduction, description of the project and its methodology, appendices are presented on: competencies for MLT and MT students; objectives; pre-test and post-test; lecture outline; and learning experiences, which included the critical care laboratory, SMA 12/60 laboratory, special chemistry laboratory, toxicology laboratory, and endocrinology laboratory. It is suggested that because the primary purpose of competency-based instruction is to clearly define what the student is to learn and how mastery is to be demonstrated, the student must receive frequent assessment of progression toward defined goals. A bibliography is included. (LC)

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A COMPETENCY-BASED CLINICAL CHEMISTRY COURSE FOR THE ASSOCIATE DEGREE MEDICAL LABORATORY TECHNICIAN GRADUATE IN A MEDICAL TECHNOLOGY BACCALAUREATE PROGRAM

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ABSTRACT

The purpose of this project was to develop a competency-based Clinical Chemistry course for associate degree medical laboratory technicians in a medical technology baccalaureate program. Content of the course is based upon competencies expected of medical technologists at career-entry as defined in the statements adapted in 1976 by the House of Delegates of the American Society for Medical Technology. The course is designed to enable medical laboratory technicians who have developed some, but not all, of the required skills of a medical technologist to augment their knowledge and proficiency in specific units of study rather than complete the entire course.

INTRODUCTION

Associate degree medical laboratory technician (MLT) graduates bring to the academic setting an assortment of qualifications, which include technical skills in clinical areas and basic knowledge in laboratory courses. If a medical technology (MT) baccalaureate program for MLT graduates is to facilitate learning for these individuals, the clinical courses should be so structured that the students need not repeat knowledge and skills already learned.

In medical technology education for MLT graduates, it is apropos to assume that these individuals want to learn and are capable of taking on this responsibility. These students are a unique group, in that they themself have identified deficiencies which limit professional advancement. They have chosen to become involved in continuing education for professional and personal growth purposes and for documentation of advanced skills and knowledge.

The success of a MT program is determined by the degree to which the curriculum provides the students the opportunity to acquire skills and knowledge necessary to perform predetermined competencies at the baccalaureate level of proficiency. The clinical courses in this curriculum should represent a sound framework for the development and sequencing of learning experiences which will assure achievement of said competencies.

This project was undertaken to develop a competency-based Clinical Chemistry course for graduate MLT in a MT baccalaureate program. The goal of the program is to integrate past learning into a unified course of study which addresses the career mobility needs of these laboratories.

METHODOLOGY

The first step in developing this competency-based Clinical Chemistry course was to identify the competencies, course objectives and specific learning objectives based upon data obtained from task analysis. Once this was accomplished, decisions were made concerning course content and learning activities required to accomplish the objectives. The unique past learning experiences of graduate medical laboratory technicians required that attention be given to the selection of learning activities which would supplement previous skills and knowledge.

The means provided for structuring the course were a series of units arranged in basic-to-advanced increments with interrelated behavioral objectives, learning experiences, resources necessary for attainment of objectives and evaluation mechanisms. The course implements an integration of didactic and clinical experiences. This approach permits the students to obtain insight relative to expected competencies and the "reality" of a hospital clinical environment.

For the purposes of developing the course, the following steps were utilized:

1. A task analysis was performed by the Director of the Hahnemann Medical Technology Program with assistance from the Clinical Education Coordinator. This task analysis was performed to identify the characteristics of required tasks and to enumerate the skills and knowledge the student must possess in order to perform said tasks with proficiency and accuracy. In addition to the task analysis, competencies delineating medical technology and medical laboratory technician performance skills and knowledge were developed from pre-determined career-entry competencies.

2. The task analysis information and stated competencies were used to write the objectives for the course. The objectives were developed to

define what the student is to do, conditions under which the student will perform the required observable behavior and the criteria by which the student will be evaluated.

3. A criterion-referenced evaluation was developed for the purpose of determining each student's performance against predetermined standards. This evaluation is to be used for both the pre-test and the post-test. The purpose for administering the pre-test is to identify those areas the student has already mastered, allowing them to proceed to other learning activities not yet achieved.

It was the opinion of the faculty that a 50-item test was sufficient to provide an adequate sample of student achievement of the objectives. The test items reflect the instructional objectives for which the learning activities were designed. Each test item was identified with a sepcific objective from various learning experiences.

4. Learning activities were identified which consisted of a variety of instructional techniques, study questions, laboratory simulations and exposure to the hospital clinical environment. The goal of the learning experiences was to accomodate individual learning styles of the students, while assuring achievement of specific competencies.

The specific topics necessary to achieve the course objectives were organized into five learning units. Each learning unit contained the following: (1) prerequisite skills and knowledge necessary to undertake the unit, (2) objectives for each unit, (3) learning activities and/or laboratory experiences, (4) study questions, and (5) assigned reference readings.

The learning experiences and lecture outline were arranged sequentially from simple to complex tasks/knowledge. This was accomplished by starting with fact learning and then moving to higher concept and problem solving skills.

DISCUSSION

The steps in the structuring of this competency-based Clinical Chemistry course involved the development of: competencies, program objectives, curriculum sequence, learning experiences and an evaluation instrument. The design of the course was primarily fashioned on the elements necessary for competency-based instruction as defined by Broski, et al, (1977). These elements are as follows:

1. Competencies are derived from an assessment of the knowledge, skills, and attitudes needed to perform in the professional role.
2. Competencies are stated in behavioral terms. That is, behaviors of their indicators are observable and measurable.
3. Competencies are public. Students, as well as instructors, are informed as to the behaviors to be mastered.
4. Achievement of competencies is evaluated in a criterion-referenced manner. Learners are compared to performance standards rather than to other learners.
5. Instruction is self-paced. Time is allowed to vary while performance standards are held constant.
6. Learners must demonstrate mastery of prerequisite behaviors before proceeding to subsequent behaviors.
7. Learners are provided instructional alternatives appropriate to their learning style and/or preference.
8. Instruction is organized in related units called modules - each intended to enable a learner to master a competency or set of competencies. Modules generally contain these elements:
   __A statement of the competencies (behaviors, objectives) to be achieved;
   __An assessment of prerequisite skills;
   __Assessment of achievement of module objectives;
   __Diagnostic feed back cued to remediational activities, if needed.

It was the opinion of the writer that the most relevant task of this project was to identify and define entry-level competencies for both medical technologists and medical laboratory technicians in the area of Clinical Chemistry. Since the goal of the program will be to implement a career mobility program for medical laboratory technicians, it appeared extremely important

that the clinical courses eliminate repetition of previous education and work experience.

With the use of the basic processes of task analysis, it was possible to determine more specifically what the students need to learn and what need be taught. Accordingly, the students would be learning the most essential and critical knowledge and skills.

The course was developed to build upon past skills to the development of new knowledge and applications, thus discrete units with appropriate learning experiences and self-instructional materials were structured. In the sequencing of the learning experiences, it was necessary to further delineate the objectives into specific objectives for each learning unit. These sub-objectives represent a step in the continuium necessary to achieve the overall terminal competencies.

Since the primary purposes of competency-based instruction is to clearly define what the student is to learn and how mastery is to be demonstrated, the student must receive frequent assessment of progression toward defined goals. This will be accomplished by evaluating student learning while in each station unit, utilizing both clinical performance checklists and paper-and-pencil examinations.

It is the belief of the writer that one of the ways to improve the delivery of health care is to facilitate learning for existing practitioners. This can best be accomplished by means of a thorough analysis of the professional roles and by a systematic approach to instruction.

BIBLIOGRAPHY

Broski, D., et. al., 1977. Competency-Based Curriculum: A Pragmatic Approach. Jounral of Allied Health, Vol. 6, No. 1, pp. 38-44.

Hahnemann Medical College & Hospital, 1978. Clinical Rotation Contracts For MT And MLT Students. Philadelphia: Medical Technology Programs.

Henry, R., 1974. Clinical Chemistry: Principles And Techniques. New York, New York: Harper & Row, Publisher.

Medical College of Georgia, 1973. Performance Evaluation. In May, B., (Ed.) Proceedin-s Of A Training Institute. Gainesville, Fla.: Center for Allied Health Instructional Personnel.

_____, 1976. Designing Differentiated Clinical Experiences. In May, B., (Ed.), Proceedings Of A Training Institute. Gainesville, Fla: Center For Allied Health Instructional Personnel.

Teitz, N., 1976. Fundamentals Of Clinical Chemistry. Phila., Pa.: W.B. Saunders Co., Publisher.

Wolf, T., et. al., 1970. Utilization Of SMA 12/60 Charts As A Teaching Aid In Laboratory Medicine. Tarrytown, N.Y.: Technicon International Press.

APPENDIX A COMPETENCIES FOR MLT AND MT STUDENTS

CLINICAL CHEMISTRY COURSE CONTENT AND COMPETENCIES FOR MLT AND MT STUDENTS

TOPIC	LECTURE		LABORATORY	
	Basic Requirements for MLT and MT	Additional Requirements for MT	Basic Requirements for MLT and MT	Additional Requirements for MT
1. Quality Control	Knowledge of mean, standard deviation, and coefficient of variation as they apply to clinical laboratory quality control programs.	Application of principles of statistical analysis to ascertain accuracy and precision in quality control systems.	Ability to use and monitor quality control program within pre-determined parameters. Reports any deviation to supervisor.	Ability to initiate and select quality control programs and evaluate the precision and accuracy of the methods. Recognizes problems, identifies causes, determines and implements solutions.
2. Instrumentation	Knowledge of fundamental aspects of the operation, maintenance, and trouble shooting of instruments.	Analysis of the theoretical principles of instrumentation. Comprehension of preventative maintenance programs that meet with specifications of the instituion.	Ability to operate instruments including set up, routine functioning, recognition of abnormalities of operation and normal preventive maintenance.	Ability to correlate the theoretical knowledge of instrumentation with the operation, preventive maintenance and trouble shooting of instruments within pre-determined specifications.
3. Automation, single and multi channel Autoanalyzer	Knowledge of the fundamental aspects of the chemistry of reactions leading to the formation of a measurable product and the recognition of normal and abnormal states.	Comprehension of analytical chemistry as it relates to laboratory determinations including those factors, both practical and physiological which leads to abnormal values.	Ability to define the chemical reactions that lead to the product that is colorimetrically measured on single and multi channeled autoanalyzers.	Ability to discuss the principles and chemical reactions that occur and a recognition of abnormal values and practical and physiological explanations for their occurrence.
4. Critical Care Lab.	In addition to the criteria listed in items (2) and (3), special emphasis is placed on blood gases. A fundamental understanding of the physiological factors responsible for normal acid-base balance.	a) Interpretation of those factors, both practical and physiological which cause a deviation from normal acid-base balance.	In addition to the criteria listed in items (2) and (3) special emphasis is placed upon the calibration and operation of the blood gas instrument.	Trouble Shooting of the blood gas instrument and recognition of abnormal values from both practical and physiological causes.

CLINICAL CHEMISTRY COURSE CONTENT AND COMPETENCIES FOR MLT AND MT STUDENTS

TOPIC	LECTURE		LABORATORY	
	Basic Requirements for MLT and MT	Additional Requirements for MT	Basic Requirements for MLT and MT	Additional Requirements for MT
5. Manual Procedures (performed in Critical Care Lab(4), Special Chemistry(6) Endocrinology (7) Toxicology (8)	Knowledge of the fundamental aspects of the chemistry of reactions leading to the formation of a measurable product. A knowledge of the normal physiological occurrence of the compounds being measured.	Comprehension of the analytical chemistry as it relates to the manual laboratory determinations. Interpretation of those factors,practical and physiological, that lead to abnormal values.	Skill in the routine performance of these procedures and the recognition of abnormal values.	Installation,evaluation, maintenance and troubleshooting of manual methods and the ability to recognize and correct abnormal deviations.
6. Special Chemistry	Knowledge of electrophoresis and the basic factors which affect protein migration.	Comprehension of the theory of electrophoresis and the principle which affect the migration of molecules in electrical fields. Interpretation of the results and their correlation with patho-physiological states.	Demonstrate skill in the performance of electrophoretic procedures and lipoprotein fractionations.	Demonstrate skill in performance of electrophoretic procedures including protein, hemoglobin and lipoprotein fractionation. In addition,interpretation of the results and their clinical correlation with various disease states.

CLINICAL CHEMISTRY COURSE CONTENT
AND
COMPETENCIES FOR MLT AND MT STUDENTS

TOPIC	LECTURE		LABORATORY	
	Basic Requirements for MLT and MT	Additional Requirements for MT	Basic Requirements for MLT and MT	Additional Requirements for MT
7. Endocrinology	Knowledge of the basic concepts of the normally functioning endocrine system and the normal physiological occurrence of the compounds measured.	Comprehension of the physiology of the endocrine and exocrine systems. Correlation of abnormal values with various disease states and clinical evaluation of the endocrine glands. Knowledge of the theory and application of radioimmune assay techniques.	Skill in the performance of basic manual endocrinological procedures.	Recognition of abnormal values and the practical or physiological factors that may be responsible for these values.
8. Toxicology	Basic knowledge of gas chromatography and atomic absorption spectroscopy.	Comprehension of the principles of instrumentation for toxicology and correlation of laboratory results obtained with various pathological states.	Skill in performance of toxicological procedures.	Operation and maintenance of instruments. Interpretation of drugs and metabolities detected.

APPENDIX B OBJECTIVES

Clinical Chemistry Objectives

Upon completion of the Clinical Chemistry course, the student will be able to:

1. Describe principles of quality control including:
    A. Basic statistics
        1. Mean, median mode
        2. Standard deviation, variance
        3. Coefficient of variation
    B. Accuracy, precision, reliability, significant figures.
    C. Confidence limits, percentiles
    D. Distribution characteristics
    E. Development of normal values
    F. Control charts
2. Establish and monitor a system of quality control for the Clinical Chemistry Laboratory, applying basic principles of statistics.
3. Compare and contrast different chemical methods of measuring the selected substances, with attention to criteria of precision, sensitivity, specificity, and reliability.
4. Select laboratory instruments and accessory equipment common to the Clinical Chemistry Laboratory:
    A. State principles of operation, applying general knowledge of physics.
    B. Select correct instruments/equipment for given procedures.
    C. Demonstrate evidence and ability to operate instruments/equipment correctly and safely.
    D. Recognize evidence of instrument/equipment malfunction.
    E. Perform routine repair and maintenance operations on selected equipment within limits of capabilities.
5. Demonstrate ability to perform routine chemical analyses of blood and body fluids, emphasizing efficient organization, work flow and correct technique.

6. Perform complex, special and/or automated analyses for chemical constituents in blood and body fluids, demonstrating an understanding of chemical reactions and necessary test conditions.
7. Recall the biochemical and physiological basis of blood and body fluids analyzed in the Clinical Chemistry Laboratory.
8. Describe in general terms selected disease states (pathological processes) in which data produced in the Clinical Chemistry Laboratory is of diagnostic significance.
9. Recognize in vivo (physiologic/pharmacologic) and in vitro (instrumental/technical) conditions that may affect the validity of test results.
10. Evaluate results with regard to feasibility and correlation with clinical diagnosis.
11. State the chemical reactions and necessary conditions for analysis as related to commonly requested tests.
12. Collect, organize and summarize data in the evaluation and comparison of laboratory methods.
13. Establish and implement a new method in Clinical Chemistry for adaptation to a given laboratory setting.

APPENDIX C PRE-TEST AND POST-TEST

Pre-Test and Post Test

Name_____

Date_____

CLINICAL CHEMISTRY EXAMINATION

For each question, choose the one answer that is most correct.

1. The "chloride shift" implies that:
   a. For each bicarbonate ion leaving the red cell, a potassium ion goes along to preserve electrostatic neutrality.
   b. Bicarbonate leaves the red cell in the form of H_2CO_3 which is unchanged.
   c. Bicarbonate leaving the red cell is replaced by chloride.
   d. Sodium chloride leaves the cell when CO_2 is discharged at the respiratory organ.
2. On cellulose acetate using pH 8.6 buffer albumin migrates fastest primarily because:
   a. It has the lowest net charge
   b. Combination low net charge and relatively low molecular weight.
   c. It has the highest net charge.
   d. Combination of high net charge and relatively high molecular weight.
3. The test for 17-ketosteroids measures:
   a. Estrogenic hormones
   b. Androgenic hormones
   c. Follicle-stimulating hormone
   d. Ketone bodies
4. The measurement of T-4 in the serum is found to be a more specific measurement of thyroid function than the PBI. The reason for this is:
   a. The PBI does not measure triiodothyronine.
   b. The T-4 test measures thyroxine only.
   c. The T-4 test also measures inorganic iodides.
   d. The PBI does not measure inorganic iodides.

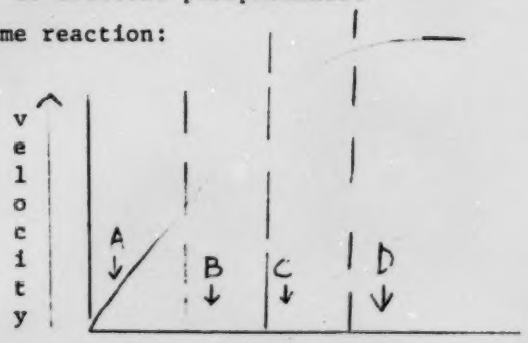
5. The wavelength used in the spectrophotometric determination of many clinically significant enzymes measuring NAD—NADH (DPN-DPNH) conversion is:

   a. 280 nanometers (millimicrons)
   b. 340 nanometers (millimicrons)
   c. 505 nanometers (millimicrons)
   d. 729 nanometers (millimicrons)

6. The enzyme which exists chiefly in skeletal muscle, heart, and brain, is grossly elevated in active muscular dystrophy, and rises early in myocardial infarction is:

   a. lipase
   b. transaminase
   c. lactic dehydrogenase
   d. creatine phosphokinase

7. Enzyme reaction:



Concentration of substrate

The graph shows the relationship of velocity of an enzyme reaction to substrate concentration. The concentration which <u>best</u> measures the activity of the enxyme is at point:

   a. A
   b. B
   c. C
   d. D

8. Determinations by atomic absorption spectrophotometry are based on the fact that:

   a. excited electrons of heated atoms emit light
   b. excited electrons of heated molecules emit light
   c. valence electrons of heated molecules can absorb light
   d. valence electrons of heated atoms can absorb light

9. The patient's blood chemistry results are as follows (all controls satisfactory): Sodium - 140 mEq/L; Potassium - 4.0 mEq/L; Chloride 130 mEq/L; CO_2 content - 25 mM/L; Arterial blood pH - 7.4. On the basis of these results:
    a. The patient's physician should be notified immediately by phone of the abnormal chloride result.
    b. The patient probably has hyperchloremic acidosis.
    c. Chloride should be repeated on a fresh sample of blood.
    d. The CO_2 content is very low, and the patient's physician should be notified immediately.
10. A blood creatinine value of 5.0 mg/100 ml is most likely to be found with which of the following blood values?
    a. uric acid 3.4 mg/100 ml
    b. urea nitrogen 15 mg/100 ml
    c. uric acid 100 mg/100 ml
    d. urea nitrogen 80 mg/100 ml
11. A procedure indicates that color development should be carried out on a 5.0 ml aliquot of 1:10 dilution of serum. Due to a laboratory accident only 4.0 ml of the well-mixed 1:10 dilution is available for analysis. One ml of water is added to the 4.0 ml of the 1:10 dilution to obtain 5.0 ml volume. This unknown has the same adsorbancy as the undiluted standard (10 mg/100 ml). The concentration of the unknown is:
    a. 25 mg/100 ml
    b. 40 mg/100 ml
    c. 80 mg/100 ml
    d. 125 mg/100 ml
12. Chemistry screening batteries and/or profiles using continuous flow analysis of discreet sampling are:
    a. Much more accurate than the individual manual methods.
    b. Best performed on fasting samples in order to compare the results with the normal ranges for those tests.
    c. Far less precise than individual manual methods.
    d. Superior to and should do away with the need for manual methods.

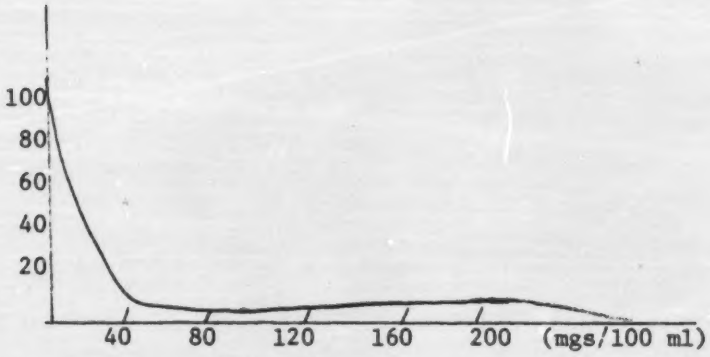
13. A fixed slit can be used with a spectrophotometer which contains a grating because:
    a. The width of the slit is made wide enough to accomodate any possible absorption.
    b. The dispersion of the light is uniform in all wavelengths.
    c. The width of the slit is only 5 nanometers.
    d. The dispersion is so inaccurate that any size slit can be used without affecting the reading.
14. The control run with a batch of unknowns is found to be 4 SD above the mean. You should:
    a. Correct the unknowns from results on the control and report.
    b. Repeat the determination on the same sample of quality control material, and if second result is satisfactory, report the unknowns.
    c. Repeat determinations on the original sample, a new sample of quality control material, at least 1 standard and several of the unknowns, and decide upon action after reviewing the results.
    d. Prepare new reagents, new standards, repeat determinations on new quality control material and repeat all of the unknowns, and then report.

Go directly to next page

15. Select the one best answer in the following multiple choice questions:

1. A sample analyzed at 10:00 a.m. had a value for total bilirubin of 15 milligrams per 100 milliliters. Late that afternoon the same sample was again analyzed for bilirubin and the result was 9 milligrams per 100 milli-leters. The probable cause of the discrepancy is that the:

a. Wrong sample was analyzed the first time.
b. Bilirubin was lost due to photo-oxidation.
c. Sample was hemolyzed and the hemoglobin deteriorated.
d. Instrument tubing was stopped up.



A calibration curve for a photometric determination in which color development follows Beer's law is shown above. The y-axis represents:

a. Length of the light path
b. Percent rransmission
c. Absorbance
d. Wave length

17-19 In a suspected case of multiple myeloma, the serum specimen contains 12 grams of protein per 100 milliliters. Urine from the same patient contains no protein measurable by the Labstix and Albutest methods. Hematology reports no plasma cells in the peripheral blood. The sedimentation rate is increased. Cellulose acetate electrophoresis of the serum and urine are performed with the results pictured on next page.

Serum

Urine

17. Which of the following methods should be used to study the protein abnormality further?
    a. Ultracentrifuge studies
    b. Blood viscosity studies
    c. Electrophoresis of penicillin in treated serum
    d. Immunoelectrophoresis
18. Which of the following is an abnormal gamma globulin producing condition consistent with the electrophoretic patterns and your knowledge of immunology?
    a. Cirrhosis of the liver
    b. Polyclonal gammopathy
    c. Monoclonal gammopathy
    d. Infectious mononucleosis
19. All available information provides evidence for:
    a. Multiple myeloma
    b. Aclonal gammopathy
    c. Monoclonal gammopathy
    d. Aggamaglobuninemia
20. A patient is brought to the hospital 4 or 5 hours after taking an overdose of barbiturates, and samples of blood and urine are taken for analysis. All of the following statements about this patient are correct EXCEPT:
    a. It is possible to measure the serum barbiturate level quantitatively by use of ultraviolet spectrophotometry.
    b. It is possible to measure the serum barbiturate level by gas chromatography on a suitable extract of serum.
    c. It is possible to demonstrate the presence of barbiturate qualitatively by chemical tests.
    d. It is possible to measure the serum barbiturate level quantitatively by atomic absorption spectrophotometry.

21. Which of the following is a correct statement comparing the results obtained on serum glucose by the continuous flow method with those obtained by a manual method utilizing glucose oxidase after protein precipitation with $Zn(OH)_2$?

    a. The results of the continous flow methods are a little higher because some saccaroids react with potassium ferricyanide.

    b. The results of the continuous flow are a little lower because not all of the glucose dialyzes across the membrane in the time period.

    c. The results of the continuous flow method are a little high because the glucose oxidase reaction is incomplete.

    d. The results of the continuous flow method are a little low because oxidation with potassium ferricyanide is incomplete.

22. You are on the HBD station. You have been following Mr. Smith's enzyme pattern for 3 days.

	Day 1	Day 2	Day 3
HBD (units)	200	550	500
SGOT (mu/ml)	150	100	75

Today his SGOT is 200 mu/ml and his HBD is 470 units. Assuming all patient identification is correct, the probable explanation is:

    a. Patient had another infarction

    b. Patient has liver complications

    c. Since HBD is still decreasing, it is not another infarction, so check the Quality Control for SGOT's.

    d. A normal occurrence - insignificant results

    e. Patient had an infarction because SGOT increased but check water bath and Quality Control for HBD's to find out why they didn't increase.

23. A serum calcium determination was requested on a patient previously diagnosed as having tetany. On day one the calcium value was reported as 7.4 mgs/dL. Two days later another sample was drawn and this value was found to be 2.5 mgs/dL. The most likely explanation for this is:

cont'd next page

a. EDTA reagent is binding too much calcium resulting in a decreased value.

b. Sample was hemolyzed resulting in a decreased value because hemolysis inhibits calcium values.

c. Sample is oxalated. Oxalate precipitates calcium resulting in a decreased value.

d. The patient is losing calcium in the urine.

Directions

Each group of questions below concerns a laboratory situation. In each case, first study the description of the situation. Then choose the one best answer to each question following it.

Questions 27-28

Serum samples are taken from a patient on admission to the hospital. The laboratory results are as follows:

Creatinine - 0.9 milligram per 100 milliliters

Lactate dehydrogenase - 60 units (normal = 15-56 units)

Sodium - 138 milliequivalents per liter

Potassium - 4.0 milliequivalents per liter

Creatinine phosphokinase - 25 units (normal = 15 - 56 units)

On samples obtained 2 days later, repeat determinations gave the following results:

Creatinine - 1.3 milligrams per 100 milliliters

Lactate dehydrogenase - 150 units

Sodium - 140 milliequivalents per liter

Potassium - 6.2 milliequivalents per liter

Creatinine phosphokinase - 27 units

. There is no clinical change in the patient's health.

27. If calibration standardization, and control of the tests are not responsible, the most likely cause of the recorded change is:

a. Subclinical deterioration of the patient

b. Hemolysis

c. Clerical error

4. An invitro anticoagulant effect

28. Correct results from the same sample could have been obtained by:
    a. Filtration
    b. Changing filters in the photometer
    c. Using different assay techniques
    d. No means at all

29 Two proteins with identical isoelectric points and molecular weights, but different solubilities in organic solvents, can be separated most effectively by
    a. Thin layer chromatography
    b. Cellulose acetate electrophoresis
    c. Paper electrophoresis
    d. Infrared spectrophotometry

30. Hemoglobin electrophoresis by the starch gel method demonstrates an abnormality when the patient has
    a. Thalassemia minor
    b. Pernicious anemia
    c. Hereditary spherocytosis
    d. Plasma cell myeloma

31. The classical Henderson-Hasselbalch equation is written below for the blood bicarbonate-buffer system. Which of the following can be substituted for H_2CO_3 ? $pH = pK + \log \frac{HCO_3^-}{H_2CO_3}$
    a. CO_2 content
    b. k x pCO_2
    c. CO_2 content - pCO_2
    d. k x HCO_3^-

Questions 32-33

Two sets of blood and urine samples are obtained from a clinic patient, the first while the patient is fasting and the second approximately 2 hours after the patient has eaten. The following test results are obtained before the patient leaves the laboratory area.

	Fasting	2 Hours Postprandial
I. Blood glucose	100mg/ 100 ml	160 mg/100 ml.
II. Urea nitrogen	35 mg/100 ml	37 mg/100 ml.
III. Aspartate amino-transferase (SGOT)	8 I.U.	8 I.U.
IV. Urine glucose	negative	1%

cont'd next page

	Fasting	2 hours postprandial
V. Uric acid (serum)	6.0 mg/100 ml	6.0 mg/100 ml
VI. Total serum cholesterol	220 mg/100 ml	235 mg/100 ml

32. The most appropriate procedure to provide important additional information in this situation would be which of the following?
    a. Getting a blood sample at 3 hours postprandial for total serum cholesterol
    b. Getting a blood sample at 3 hours postprandial for serum uric acid analysis
    c. Getting blood and urine samples at 3 hours postprandial for glucose and blood creatinine analyses
    d. Repeating the cholesterol analysis

33. You are requested to bring significant abnormalities in results to the attention of the physician by telephone. You should telephone him about which of the tests?
    a. I and VI only
    b. III and IV only
    c. I, II and IV only
    d. II, IV, and VI only

Questions 34-35 refer to a sample of blood from a 68-year-old patient who is unconscious. The blood is sent to the laboratory for emergency determinations. The blood sugar is found to be 580 milligrams per 100 milliliters.

34. The sample is likely to show which of the following with respect to pH and CO_2 content?
    a. High pH and high CO_2
    b. High pH and low CO_2
    c. Low pH and normal CO_2
    d. Low pH and very high CO_2
    e. Low pH and low CO_2

35. An important determination to perform on a urine sample obtained at about the same time as the blood sample is
    a. Hydroxyproline
    b. Calcium
    c. Acetone
    d. Bilirubin
    e. Creatinine

36. For accurate and reproducible photometric analysis, the chemical reactions involved need not go to completion when using continuous flow instrumentation if

    a. The dialyzer is removed from the continuous flow scheme
    b. All pump tubes have the same inside diameter
    c. The pumping rate and the volume of the system remain constant
    d. The heating bath has a variable temperature setting

37. The heating bath is used in continuous flow instrumentation to

    a. Destroy substances that interfere with the colorimetric method
    b. Increase the rate of the chemical reactions
    c. Precipitate serum proteins that interfere with most colorimetric methods
    d. Remove segments of air from the recipient stream prior to the material entering the colorimeter

Go directly to next page

In the following questions(38-47) match the numbered questions with the lettered items.

In laboratory quality control programs:

____ A. Values increase or decrease in succession from the mean

____ B. Simulates plasma, serum, urine, or CSF

____ C. Well-characterized chemical solution of known specific value

____ D. Aids in detection of technical error

____ E. Congregating of values on either side of the mean

38. Shift

39. Standard Solution

40. Trend

41. Control Solution

42. Quality Control

Instrumental analysis:

43____ A. A gas diffuses across a gas permeable membrane, the product of this reaction is carbonic acid and it is measured with a pH electrode system.

44.____ B. Measures the radiant energy given off as the element returns to its lower energy level

45____ C. Absorption of light at one wavelength and emission of light of a longer wavelength and lower energy

46____ D. A gas diffuses across a gas permeable membrane, a current is produced which is directly proportional to the tension of diffusing gas

47____ E. Measures the monochromatic light absorbed by the ground state atoms

Atomic Emission

Fluorometry

Atomic Absorption

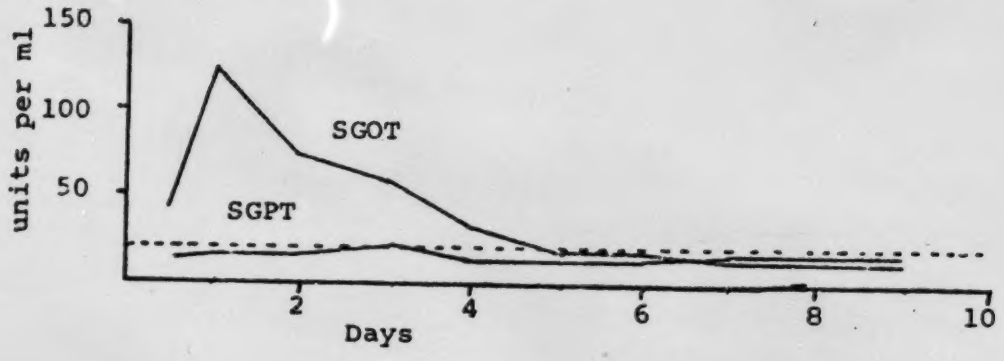
pCO_2 electrode

pO_2 electrode

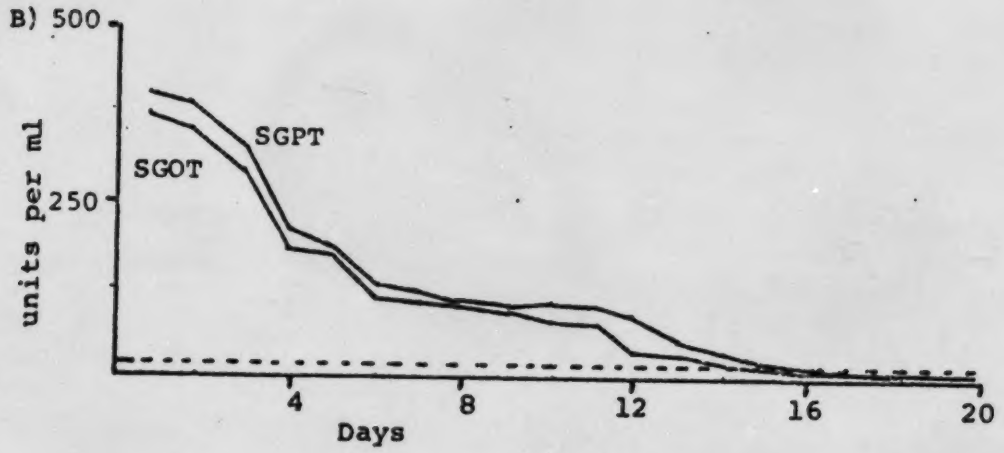
Which serum transaminase pattern is most characteristic of:

48. viral hepatitis _____
49. myocardial infarction _____
50. infectious mononucleosis _____

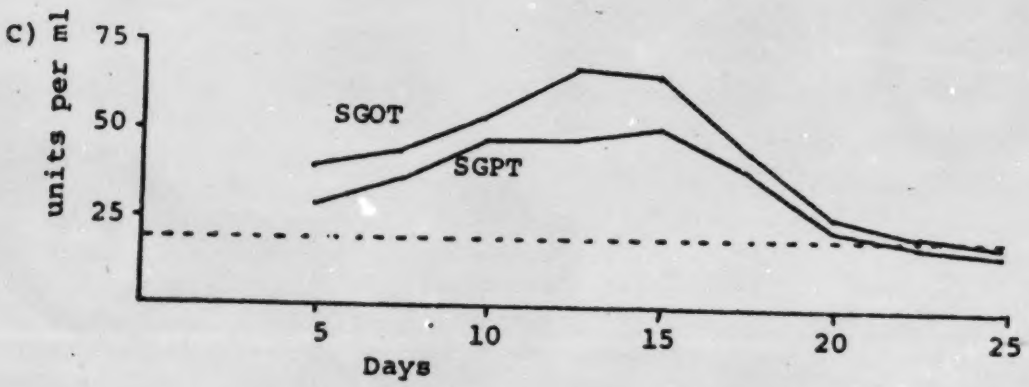
A)



B)



C)



APPENDIX D LECTURE OUTLINE

ADVANCED CLINICAL CHEMISTRY

LECTURE OUTLINE

Topics	No. of Lectures
Analytical Procedures And Instrumentation	3
1. Absorption Spectrophotometry	
2. Flame Photometry	
3. Atomic Absorption Spectrophotometry	
4. Electrophoresis	
5. Gas Chromatography	
Quality Control	2
1. Statistics in the Clinical Chemistry Laboratory	
2. Normal Values	
3. Quality Control Programs	
Carbohydrates	3
1. Chemistry of Carbohydrates	
2. Utilization of Carbohydrates	
3. Carbohydrate Metabolism	
4. Disturbances in Carbohydrate Metabolism	
5. Determination of Carbohydrate	
6. Glucose tolerance	
Protein	3
1. Chemistry of Amino Acids and Proteins	
2. Utilization of Proteins	
3. Protein Metabolism	
4. Distrubances in Protein Metabolism	
5. Determination of Proteins and Non-protein Nitrogen Compounds	
Lipids	3
1. Chemistry of Lipids	
2. Utilization of Lipids	
3. Metabolism of Lipids	
4. Disturbances in Lipid Metabolism	
5. Determination of Lipids	

	No. of Lectures
Enzymes	3
1. Definition and Nomenclature	
2. Enzyme Kinetics	
3. Determination of Enzyme Activities	
4. Enzymes in Clinical Practice	
Acid-Base Balance	3
1. Body water	
2. Basic Acid-Base theories	
3. Acid-Base Balance in man	
a. Production of $[H^+]$	
b. Removal of $[H^+]$	
c. Production of $[HCO_3^-]$	
d. Removal of $[HCO_3^-]$	
4. Disturbances in the normal acid-base	
a. Metabolic acidosis and alkalosis	
b. Respiratory acidosis and alkalosis	
c. Compensation of acid-base imbalance	
Mineral Metabolism	2
1. Metabolism of Electrolytes and Trace Elements	
2. Determination of Specific Electrolytes	
3. Disturbances in the Normal Metabolism of Body Water and Electrolytes	
Liver Function	2
1. Normal Function of the Liver	
2. Tests for Liver Function	
3. Clinical Significance of Liver Function Tests	
Endocrine Function	3
1. Nature and Action of Hormones	
2. Control of Hormone Secretion	
3. Tests for Endocrine Function	
4. Clinical Significance of Endocrine Tests	

	No. of Lectures
Analysis of Drugs and Toxic Substances	3
1. Drug Screening	
2. Gases, Metals and Nonmetals	
3. Nonvolatile Organic Substances	
4. Therapeutic Monotoring of Drugs	

APPENDIX E LEARNING EXPERIENCES

Learning Experiences

The primary function of the Clinical Chemistry Laboratory is the measurement of chemical changes in the body in the interest of diagnosis, therapy and prognosis of disease. Normally, the concentration of the chemical constituents in the blood and other body fluid are relatively constant, but in disease states their level becomes altered, the magnitude of change usually paralleling the degree of disease.

Most chemistry test procedures are quantitative in nature and require careful, precise measurement. An understanding of the principles of the testing methods and knowledge of the medical uses of the determinations will provide the necessary background both for performing the tests and for understanding the rationale of each.

A knowledge of the working of the human body under normal conditions is essential for the understanding of the changes that occur in pathological states. Thus, it is essential that the student review the major components involved in normal metabolism and growth. In addition, it is expected that each student possess the pre-requisite knowledge defined for each laboratory area before undertaking a specific laboratory experience.

The learning activities the student will encounter during the laboratory experiences will be a series of station rotations. At each station the student will perform and/or observe routine and special procedures with particular emphasis on precision and accuracy. The student will be guided through each station by personal instruction from the technologist performing the determination and the teaching supervisor.

The student will receive check sheets and study questions which must be completed before proceeding to the next laboratory area. No specific time will be identified for completing the requirements for the station rotations. The student will proceed through the laboratory experiences at his/her own pace. Each student will prepare a notebook which will be submitted to the teaching supervisor at the end of each laboratory area. The notebook should contain:

1. Results of determinations performed
2. Answers to study questions
3. Results of learning experiences

4. It is suggested that lecture notes be included in the notebook.

Upon completion of the requisite learning experiences for each station, a written quiz will be given. After the student satisfactorily fulfills the competencies stated for this Clinical Chemistry course, a written and practical examination will be administered. The summarized and analyzed evaluations from this examination will provide the information relative to procifiency in performance, grading and advancement.

Critical Care Laboratory

Subject: Bicarbonate, pH, CO_2, pO_2
Glucose, BUN and Electrolytes

Instrumentation: Blood Gas Analyzer
Chloride Meter
Flame Photometer

Pre-Requisite Skills:

1. Discuss the following components of the test procedure:
   a. Principle
   b. Procedure
   c. Specimen Collection
2. Interpret the results of each test procedure in terms of:
   a. Normal and abnormal results
   b. Relation to physiology
   c. Relationship with other laboratory data
3. Discuss the basic theory of operation of the instrumentation used in the Critical Care Laboratory including:
   a. Listing and explaining the operation of the essential components of the instruments
   b. Describing the mechanism of operation of each instrument

The pre-requisite skills are acquired through independent readings (laboratory manual, reading references) and through a review of lecture material.

Behavioral Objectives

Upon satisfactory completion of the Critical Care Laboratory rotation, and lecture series, the student will be able to:

1. Discuss the following components of the test procedure:
   a. Principle
   b. Procedure
   c. Specimen collection

2. Differentiate between normal and abnormal test results.
3. Discuss the theory of operation of the instruments used in the critical care laboratory including:
   a. the physical principles involved in operation
   b. the chemical principles involved in operation
4. List and explain the operation of the essential components of the instruments used in the Critical Care Laboratory.
5. Set up each analytical system performed in the Critical Care Laboratory.
6. Perform the test analysis assigned by the teaching supervisor according to prescribed methodology.
7. Obtain analytical data and convert, where applicable, to test results.
8. Evaluate the validity of data in relation to the test system.
9. Identify special precautions and sources of error for each of the procedures. Describe troubleshooting mechanism, when appropriate.

Learning Experiences

____1. a. Read the test principle and procedure in the designated laboratory manuals and reading resources.
   b. For each test procedure listed under the SUBJECT, select and organize sample reference materials and reagents according to the specifications of the assay.
   c. Select equipment and instruments appropriate for the measurement and specificity requirements of the analytical measurement and specificity requirements of the analytical system.
   d. For each test procedure listed under SUBJECT, describe where appropriate, special precautions which must be observed when collecting the specimen. Record in notebook.

____ 2. Given a series of test results be able to indicate whether the results are within normal range or abnormal.

____ 3-4. Given a diagram of the components of each instrument listed under instrumentation, be able to arrange the components in the proper sequence and be able to explain the operation of each component.

____ 5-7. For specific test procedure listed under SUBJECT perform:

a. 20 determinations with the appropriate controls (blood gas)

b. 10 determinations with the appropriate controls (electrolytes)

c. 16 determinations with the appropriate controls (glucose and BUN)

d. 5 determinations with the appropriate controls (CO_2)

Record all results in a notebook.

____ 8. Evaluate the acceptability of control samples. Record in student notebook.

____ 9a. During the critical care laboratory rotation, make written notes on all special precautions and possible sources of error, (including instrumentation) for each of the test procedures listed under SUBJECT. Record in student notebook.

____ b. For at least four (4) sources of error discuss the procedure for recognizing and correcting the error (troubleshooting). Record your findings in student notebook.

____ c. Answer the attached study questions. Record in student notebook.

Reading references: Elementary principles of Laboratory Instruments by Leslie W. Lee

Chapter 4 Spectrophotometry

Chapter 5 Light emission and absorption measurement

Chapter 7 Electrochemistry and measurement of pH.

Fundamentals of Clinical Chemistry by Norbert W. Tietz

Chapter 3 Instrumentation

Chapter 6 Carbohydrates

Chapter 15 Blood Bases and Electrolytes

Chapter 16 Acid-Base Balance

Chapter 17 Renal Function

Study Questions Critical Laboratory

1. After running several blood pH's, erratic results may be obtained. The most likely cause is:

   a. Static electricity
   b. Protein fouling of the electrode
   c. Faulty electrode
   d. Faulty meter

2. The "chloride shift" implies that:

   a. for each bicarbonate ion leaving the red cell, a potassium ion goes along to preserve electrostatic neutrality.
   b. bicarbonate leaves the red cells in the form of H_2CO_3, which is unchanged.
   c. bicarbonate leaving the red cells is replaced by chloride.
   d. sodium chloride leaves the cell when CO_2 is discharged.

3. There are many methods for the determination of Cl^-. Match the listed final end-product (Column B) with its method in Column A. (An answer may be used more than once).

Column A - Methods	Column B - End Products
_____ Schales and Schales	A. Mecuric Chloride
_____ Cotlove (Colometric) Titrator	B. Silver Chloride
_____ Autoanalyzer	C. Ferric Thiocyanate
	D. Ferric nitrate
	E. Mercuric nitrate

4. Prolonged nasal suction without adequate intravenous replacement therapy results in :

   a. hypokalemic alkalosis
   b. metabolic acidosis
   c. increased serum potassium
   d. decreased serum CO_2 content

5. CO_2 is converted in the body to carbonic acid by the action of a (an):

   a. catalase
   b. oxidase
   c. anhydrase
   d. peroxidase

Go directly to next page.

6. Situation: A blood specimen submitted for lithium analysis on the IL (Instrumentation Laboratory) flame photometer was found unsuitable for the determination because there was an improper ratio with the internal standard. The most likely reason would be:

   a. serum was lipemic
   b. serum is hemolyzed
   c. patient was not basal
   d. presence of a chelating agent in the glassware

7. If blood is exposed to air:

   a. the CO_2 content increases and the pCO_2 and pH decrease.
   b. the CO_2 content and pCO_2 increase and the pH decreases.
   c. the CO_2 content and pCO_2 decrease and pH increases.
   d. the CO_2 content decreases and the pCO_2 increases.

8. Spectral interference in flame emission photometry is eliminated by having a:

   a. chopper
   b. cathode tube
   c. chelating agent
   d. narrow band pass monochromator

9. Fluctuation in the needle on a Cotlove titrator is most probably due to:

   a. common ion effect
   b. lack of indicator
   c. bad reference voltage
   d. dirty electrodes

10. The statement which most currently describes the measurement of pH with a glass electrode is:

   a. hydrogen ions pass through a special kind of permeable glass
   b. the internal and external half-cells have the same potential
   c. a special kind of glass sensitive to hydrogen ions is used
   d. the temperature knob on the pH meter compensates for the influence of temperature

11. Situation: In the midst of a sodium and potassium run on the IL flame photometer, the lithium needle falls below the set level. The most likely cause is:

   a. clogging of the aspiration needle
   b. change in the concentration of the lithium
   c. low fuel supply
   d. low air supply

12. Below are laboratory results obtained on three patients. Correlate the findings of each numbered item with the probable explanation found among the optional answers below:

	CO_2 content mM/L	pCO_2 mm Hg	pH
_____	30	60	7.30
_____	16	26	7.38
_____	14	30	7.28

a. uncompensated metabolic acidosis
b. compensated metabolic acidosis
c. uncompensated respiratory acidosis
d. compensated respiratory acidosis

13. Hypernatremia is seen in :

a. diabetes insipidus
b. dehydration
c. starvation
d. Addison's Disease

14. Respond to the following items by matching the correct alternative in Column B with the item numbered in Column A. An answer may be used more than once.

Column A	Column B
_____ Serum HCO_3 - increases	A. respiratory alkalosis
_____ Serum pCO_2 decreases	B. metabolic alkalosis
_____ Serum pCO_2 increases	C. both respiratory alkalosis and metabolic alkalosis
_____ Urine pH increases	D. neither respiratory alkalosis nor metabolic alkalosis
_____ Urine pH decreases	

15. A key factor in cell membrane permeability is:

a. the size of the connective tissue molecules
b. the amount of glycoprotein present
c. the Na^+ and K^+ PUMP
d. the presence of lipoproteins

16. Normal values vary from laboratory to laboratory. In general, however, there are some ranges which are generally accepted. Match these adult serum (plasma) ranges (column B) with the appropriate determinations in column A.

	Column A	Column B
_____	Ca^{++}	A. 8.5-10.5 mg/100 ml
		B. 1.8-3.0 mg/100 ml
_____	Mg^{++}	C. 3-4.5 mg/100 ml
		D. 250-350 ug/100 ml
_____	Fe^{+++}	E. 50-150 ug/100 ml
		F. 135-145 mEq/1
_____	Na^{+}	G. 24-30 mM/1
		H. 9-15 mM/1
_____	Cl^{-}	I. 95-105 mEq/1
		J. 3-5%
_____	CO_2	
	Whole Blood (Arterial)	
_____	pH	K. 35-45 mm Hg
		L. 7.35-7.45
_____	O_2 saturation	M. 7.25-7.35
		N. 80-90 mm Hg
_____	pCO_2	O. 96-97%
		P. 85-90%
_____	HCO_3^{-}	Q. 22-28 mM/1

17. When the pH of a solution changes from pH 5 to pH 3 the hydrogen ion concentration changes:

a. 2 fold
b. 10 fold
c. 20 fold
d. 100 fold

Questions 18-19 The basic modules for Autoanalyzer analysis are pictured in Figure 3. Match the numbered modules in Column B with the determinations in Column A.

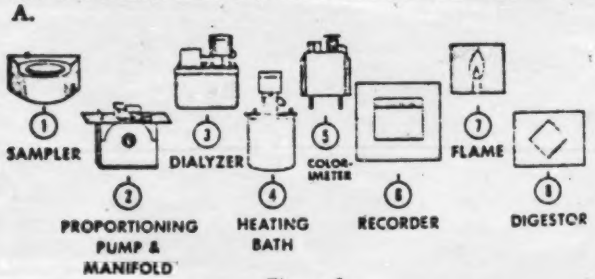


Figure 3

Column A - Determinations	Column B - Modules
	a - 1, 2, 3, 7, 6
18. CO_2	b - 1, 2, 3, 4, 5, 6
	c - 1, 2, 8, 7, 6
19. Na^{+}/K^{+}	d - 1, 2, 3, 5, 6
	e - 1, 2, 5, 6

20. Define what is meant by electrolyte balance or balance of electroneutrality. Give examples.

21. SITUATION: Four "normal" serum specimens were analyzed with the four sets of results listed below. The set of results most likely in error is:

	HCO_3^- meq/l	Cl^- meq/l	Na^+ meq/l
A.	18	103	135
B.	35	90	138
C.	24	103	128
D.	27	97	136

22. The anticoagulant of choice to use for the collection of blood gas specimens is:

A. fluoride
B. sodium oxalate
C. EDTA
D. Heparin

23. SITUATION: A supervisor looked at the following blood gas results:

	Patient I	Patient II
pO_2	82 mm Hg	82mm Hg
O_2 saturation	92.7%	96.4%
pH	7.30	7.49

The supervisor observes the same pO_2 values with different saturation values. This is best explained by:

A. an error in calculation
B. a faulty oxygen electrode
C. the effect of pH on O_2 dissiciation curves
D. the loss of anaerobiosis on one of the specimens

SMA 12/60 Laboratory

Subject: Biochemical Profile

Instrumentation: SMA 12/60

Pre-requisite skills:

1. Discuss the theory of operation of the SMA 12/60 including:
    a. the physical principles involved in operation.
    b. the chemical principles involved in operation.
2. List and explain the essential components of the SMA 12/60.
3. Describe the mechanism of operation of the SMA 12/60.

The pre-requisite skills are acquired through independent reading (laboratory manual, reading references) and through a review of lecture materials.

Behavioral Objectives:

Upon satisfactory completion of the SMA 12/60 rotation and the lecture series, the student will be able to:

1. Interpret the results of each procedure in terms of:
    a. normal and abnormal results
    b. relation to physiology
    c. interrelationship with other laboratory data
2. Discuss the following components of the test procedure:
    a. principle
    b. procedure
    c. specimen collection
3. Set up each analytical system performed in automated chemistry.
4. Perform the test analysis assigned by the teaching supervisor, according to prescribed methodology.
5. Obtain analytical data and convert, where applicable, to test results.
6. Evaluate the validity of data in relation to the test system.
7. Correlate the test results with disease states.
8. Identify special precautions and sources of error for each of the procedures. Describe troubleshooting mechanisms, where appropriate.

Learning Experiences:

____ 1. Given a list of the determinations performed by the SMA 12/60, be prepared to match the determination with the appropriate:
(a) Principle
(b) Procedure

____ 2. Day 1 and 2. Make up reagents, change pump tubes as well as numbering the work and setting sample trays. Set up the instrument, balance colorimeter and phase the instrument. Run the instrument with the technologist.
Day 3 and 4 Run the instrument from start to shut down independently. The student will be able to recognize problems, identify causes, determine and solve problems. Check quality control of the instrument.

____ 3. a. Refer to daily schedule.
b. Read the test procedure designated in the laboratory manual
c. For the test procedure listed under SUBJECT, select and organize sample reference materials, and reagents according to the specifications of the assay.

____ 4-5. Perform the appropriate controls and patient specimens.

____ 6. Review values obtained for standards and controls for their acceptability. Record findings in the student notebook.

____ 7. In addition to the SMA 12/60 profiles attached,the student should be able to explain the correlation in the abnormal laboratory results obtained during the clinical rotation and the corresponding disease states. Record abnormal findings in notebook.

____ 8. a. Answer each of the attached study questions. Record in notebook.
b. During the SMA 12/60 chemistry rotation, make written notes on all special precautions and possible sources of error for each of the procedures. Record in notebook, in table form.
c. Complete the SMA 12/60 study questions.

Reading references:

Fundamentals of Clinical Chemistry - Norman Tietz

Chapter 4	Automation
Chapter 6	Carbohydrates
Chapter 7	Proteins and Amino Acids
Chapter 19	Liver Function

Study Questions

1. What is the purpose of pre-dilution? How many determinations are pre-diluted? What is the pre-dilution ratio?

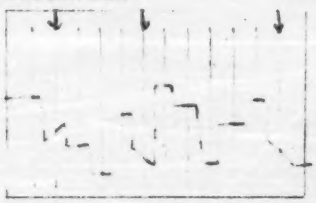
2. Explain the difference between an ordinary chemistry curve and the steady-state plateau.

3. Explain the difference between the basic analyzer cam and the SMA 12/60 cam?

4. Why are air bubbles used in the autoanalyzer? How often are air bubbles inroduced into the system? What is the means of inroduction?

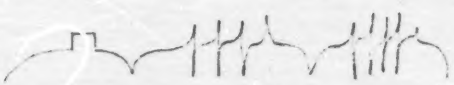
5. Describe the analytical cartridge.

6. If your reference sample looked like the chart pictured below, what would you do to correct the situation?



7. How do your balance each colorimeter sample channel against the reference channel? Why must a colorimeter be balanced?

8. The following picture appears on your function monitor. What is the problem? How can it be corrected?



9. Why is 340 nm wavelength used for the LDH and SGOT enzyme determinations? Explain why other wavelengths could not be used.

10. Give the principle, reagents, normal values and clinical significance for the following determinations on the SMA 12/60: (REPORT in TABLE-FORM.)

    a. Calcium
    b. Inorganic Phosphorus
    c. Uric Acid
    d. Cholesterol
    e. Total Protein
    f. Albumin
    g. Total Bilirubin
    h. Alkaline Phosphatase
    i. LDH
    j. SGOT

11. Explain the step-by-step procedure for shutting down the SMA 12/60.

12. You do not have a stopwatch. Explain two ways that you can tell when the first sample is coming through.

13. How often should pump tubing be changed? Why does it have to be changed?

14. How could you tell if your bilirubin cartridge is not getting proper reagents?

15. If suddenly all the LDH's went to the top of the chart and all other tests were normal, what would you suspect had happened?

16. All components on the SGOT cartridge are functioning properly. You have an adequate supply of reagents pumping through, but your SGOT sample is 6. What should you do?

Auto Analyzer Worksheet

1. Air is used to segment a stream in order to _____.

   a. reduce color-reaction time
   b. conserve available sample and reagents
   c. prevent samples from contaminating each other

2. A distilled water wash is used _____.

   a. between sample cup aspirations
   b. between standards only
   c. for end-of-day system washout only

3. The Sampler holds and delivers _____.

   a. standards only
   b. unknowns, standards, and wash
   c. unknowns only

4. The sample-to-wash ratio is mechanically controlled by a _____.

   a. last-stop pin
   b. adapter plate
   c. cam

5. In the AutoAnalyzer, chemical reactions are taking place on streams that are flowing in a steady, uninterrupted manner. This technique of chemical analysis is called _____.

   a. multi-channel
   b. continuous flow
   c. segmented dialysis

6. Which is the filtration module? _____.

   a. Proportioning Pump & Manifold
   b. Dialyzer
   c. Sampler

7. After the recipient stream leaves the Dialyzer, where does the stream usually go? _____

   a. To the Colorimeter
   b. To waste
   c. To the Heating Bath

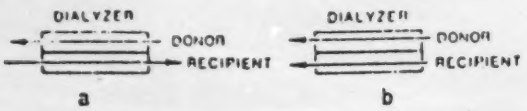
8. How much of the donor constituents passes through the membrance to be picked up by the recipient stream? _____

   a. small amount
   b. about half
   c. almost all

9. In the Dialyzer, what separates the donor stream from the recipient stream? _____

   a. helical grooves
   b. porous membrane
   c. balanced segmentation

10. In the figure below, which Dialyzer flow is correct _____.



11. How many plates of the dialyzer are under water? _____.

   a. Donor plate only
   b. Recipient plate only
   c. Both a and b

12. The Heating Bath heats the recipient stream to _____.

   a. accelerate a color reaction
   b. prevent a color reaction
   c. remove the air bubbles

13. In the Heating Bath, using a color producing method, how is an incoming highly concentrated red stream affected? _____.

   a. The color becomes lighter.
   b. The color remains unchanged.
   c. The color becomes darker.

14. Leaving the Heating Bath, the recipient stream usually goes directly to the _____.

   a. Recorder
   b. Sampler
   c. Colorimeter

15. In the stream under analysis, the Colorimeter measures _____.

   a. color
   b. percentage-of-light transmittance
   c. specific gravity

16. Measurements are made on the stream as it passes through the Colorimeter _____.

   a. reference photocell
   b. flowcell
   c. sample photocell

17. When the output signals of the two Colorimeter photocells are electrically balanced, the Recorder pen will _____ .

    a. move from 0 to 100
    b. remain stationary
    c. move from 100 to 0

18. A beam of light passes through the stream in the flowcell to strike the _____ photocell.

    a. tungsten lamp
    b. reference
    c. sample
    d. 100% T

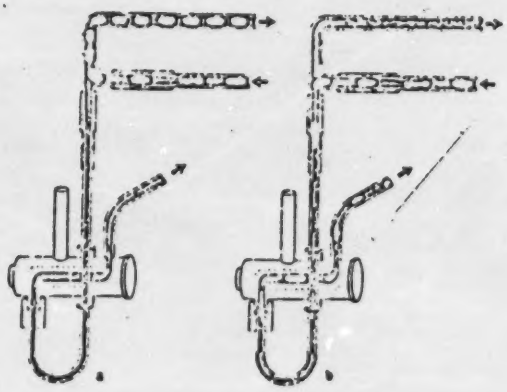
19. A stream possessing 100% T will pass what amount of light? _____

    a. All
    b. About Half
    c. None

20. In readying the colorimeter for operation, the reference photocell and the sample photocell are adjusted to produce _____.

    a. zero output voltages
    b. equal output voltages
    c. maximum output voltages

21. In the figure below, which represents the correct action that occurs within the flowcell and debubbler? (a or b) _____

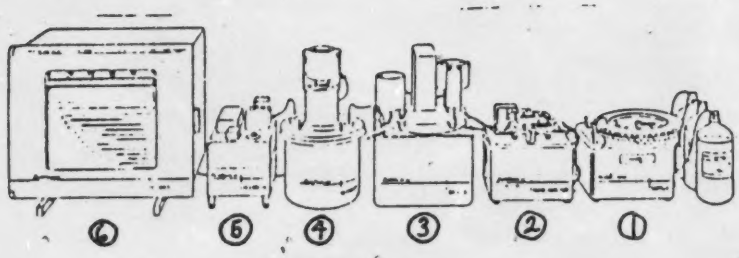


22. In a given Method, how many recorded peaks will 12 different sample cup aspirations produce? _____

    a. 6
    b. 12
    c. 24
    d. 48

23. Identify, by name, the modules shown in the figure below.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____



SPECIAL CHEMISTRY

SUBJECT:

Enzyme determinations
Hemoglobin electrophoresis
Protein electrophoresis, Immunoelectrophoresis,
Lipoprotein electrophoresis
Isoenzyme electrophoresis (CPK, LDH)
Miscellaneous manual procedures (total protein for CSF and urine, fetal hemoglobin denaturation, lipase, amylase, acid phosphatase, cholesterol and bilirubin)
Complement:
Immunoglobulins
Alpha feto proteins
L/S ratio

INSTRUMENTATION:

Electrophoretic Equipment
Single Channel Autoanalyzer
Thin Layer Chromatography

PRE REQUISITE SKILLS:

1. Explain the normal and abnormal physiology related to each of the test results.
2. Discuss the following components of the test procedure:
   A. Principle
   B. Procedure
   C. Specimen Collection
3. Interpret the results of each test procedure in terms of:
   A. Normal and abnormal results
   B. Relation to physiology
   C. Interrelationship with other laboratory data
4. Discuss the theory of operation of the instrumentation used in the Special Chemistry Laboratory including:
   A. The physical principles involved in operation
   B. The chemical principles involved in operation

5. List and explain the operation of the essential components of the instruments used in Special Chemistry.
6. Describe the mechanism of operation of each instrument.

The pre-requisite skills are acquired through independent readings (laboratory manual, reading references) and through a review of lecture materials.

BEHAVIORAL OBJECTIVES:

Upon satisfactory completion of the Special Chemistry rotation, the student will be able to:

1. State the principle of each Special Chemistry procedure.
2. Describe the procedures for specimen collections.
3. Determine normal or significant test values for locality, indivduals and source of sample according to established protocols.
4. Determine appropriate methods for specific test procedures.
5. Set up each analytical system performed in Special Chemistry.
6. Perform each tests analysis according to prescribed methodology.
7. Obtain analytical data and convert, where applicable, to test results.
8. Evaluate the validity of data in relation to the test system.
9. Correlate the test results with other patient data.
10. Determine if additional analysis are needed for clarification of test results.
11. Report results through appropriate systems conforming to established procedures.
12. Identify special precautions and sources of error for each of the procedures. Describe troubleshooting mechanism, when appropriate.
13. Describe the use of the instruments involved in the test procedures.

LEARNING EXPERIENCES:

____ 1. All students are responsible to know the principle of each Special Chemistry procedure listed under SUBJECT on page 1. Record principles in notebook.

____ 2. For each of the procedures performed in the Special Chemistry laboratory, describe the procedure for specimen collection including:
   a. time of collection
   b. status of the patient
   c. handling of specimen

cont'd. next page

d. medico-legal requirements, where applicable

e. deterioration of constituents over time, temperature and light restriction.

Record this information in your notebook, in table form.

____ 3. For all the tests listed under SUBJECT, read the test procedure in designated laboratory manual.

____ 4. For each test procedure listed under SUBJECT, select and organize at least 2 samples, controls, and reagents according to the specifications of the assay. Perform the procedure under the supervision of the teaching technologist.

____ 5. Record the results for all test procedures, including controls, in the same manner as these results are listed on LPE data sheets.

____ 6. Review the values obtained for your standards and/or controls for their acceptability. For any standards and/or controls that are out of range record your course of action.

____ 7. For each of the procedures listed under SUBJECT, state in table form the protocol for reporting results including:

1. The established system for reporting routine and emergency tests.

2. The parameters which dictate immediate notification.

Record in student notebook.

(ex.)	Test	Results Abnormal	Results Normal	Reporting Method
	X			Immediate notification,* telephone call
	X			Written report within 24 hours
	Y			Immediate notification*

* explain in paragraph form.

____ 8. During the Special Chemistry rotation, make written notes on all special precautions and possible sources of error (including instrumentation) for each of the procedures, and the course of action for correcting each of the errors (troubleshooting).

____ 9. Answer the two questions that follow:

a. You are assigned the acid phosphatase test for the day. You set up your controls and patients according to the procedure listed in the department manual; however, when you read your tubes on the spectrophotometer, all tubes (controls and patients) read 0. What could be the reason for this?

b. A technologist ran the amylase test in Special Chemistry today. During the procedure, she could not locate the forceps for dropping the amylase tablets into the tubes, so she washed her hands and then she added the tablets to the tubes using her fingers for the transfer. Would this technique alter her results? If so, how?

___ 10. Answer each of the attached case study, study questions, laboratory safety questions, and quality control questions. Record in student notebook.

READING REFERENCES:

1. Fundamentals of Clinical Chemistry - Norman Tietz

pp.	291-292	Complement
	305-312	Protein electrophoresis
	315-319	Immunoelectrophoresis and Immunodiffusion
	343	Haptoglobin
	368-374	CSF proteins
	425-428	Hemoglobin electrophoresis
	529-536	Lipoproteins and Lipoprotein Electrophoresis
	597-600	Isoenzymes
	602-604	Alkaline Phosphatase
	613-614	Acid Phosphatase
	625-630	Amylase
	633-636	Lipase
	652-655	LDH and isoenzymes
	682-686	Creatine Kinase and isoenzymes
	689-690	
	690-692	Aldolase
	921-926	Iron and total iron binding capacity
	1026-1062	Liver Function

2. Clinical Diagnosis and Management by Laboratory Methods - Henry (16 th edition)

pp.	228-257	Haptoglobin
	1020-1024	Fetal Hemoglobin electrophoresis
	228-257	Protein electrophoresis and immunoelectrophoresis
	189-227	Lipids and lipoprotien electrophoresis
	294-298	Iron and total iron binding capacity
	347-383	Acid and Alkaline Phosphatase Aldolase, LDH and isoenzymes Leucine Adminopeptidase
	372-377	Creatine Kinase
	738-757	Amylase and Lipase
	305-347	Evaluation of the function and integrity of the liver

Special Chemistry

Case History

A 45 year old patient is brought to the emergency room complaining of severe indigestion and shooting pains into her left jaw for 2 days. The attending physician orders the following tests:

CBC
Urinalysis
Cardiac Enzyme Profile
ESR
PT/PTT
Amylase

The Stat lab reports the following results:

CBC: normal
Urinalysis: normal
ESR: 35 mm/hr (Normal: Female 50 yrs.: 0-20 mm/hr.)
CK: 137 mU/ml (Normal: 0-74 mU/ml)
LDH: 625 mU/ml (Normal: 80-250 mU/ml)
SGOT: 95 mU/ml (Normal: 8-50 mU/ml)
PT: normal
PTT: normal
Amylase: normal

1. Based on clinical symptoms and the stat lab data, what is the most probable diagnosis? (support your answer).

2. If the patient is admitted to the hospital, what additional laboratory tests may be ordered?

3. What is the most probable cause of the shooting pain?

Special Chemistry

Study Questions

1. Electrophoresis involves movement of:

   a. charged particles in a magnetic field
   b. ions along a supporting medium in a non-electrical field
   c. charged particles in an electric field
   d. protein in an electrical field using a buffer at its isoelectric point

2. Which electrophoretic fraction would be increased in the serum from a patient with an autoimmune disease?

   a. $alpha_1$ globulins
   b. $alpha_2$ globulins
   c. beta globulins
   d. gamma globulins

3. A doctor suspects that his patient has acute pancreatitis. The lipase is elevated but the amylase is normal. How would the physician interpret these results?

   a. The physician would have the amylase repeated the following day knowing that by that time, it would be elevated.
   b. The physician realizes the patient had the attack three days previous to blood testing which would therefore give the amylase a chance to return to normal.
   c. The physician will relize that in cases of acute pancreatitis, lipase is elevated at least three days before amylase.
   d. The physician will view these results as a confirmation of his diagnosis of pancreatitis.

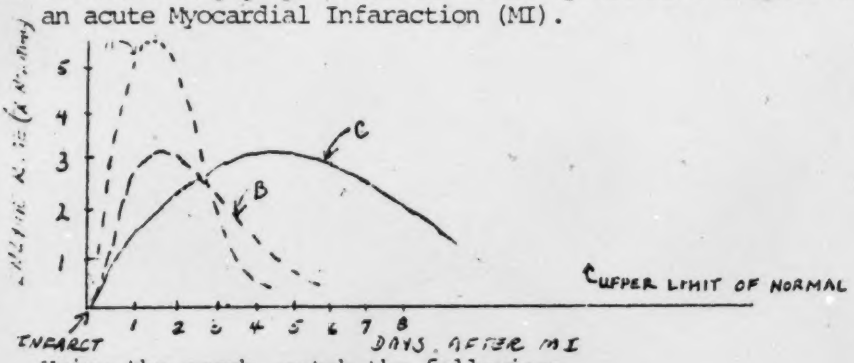
4. On a lipoprotein electrophoretic pattern, hypercholesteremia will show up as a heavy band of:

   a. alpha lipoprotein
   b. pre-beta lipoprotein
   c. beta lipoprotein
   d. chylomicrons

5. The post prandial hyperlipemia which results after a heavy meal and may give serum a characteristic "milky" appearance, is due to the presence of which of the following type of lipoprotein?

   a. chylomicrons
   b. alpha lipoprotein
   c. pre-beta lipoprotein
   d. beta-lipoprotein

6. The following graph shows the activity of three enzymes which become elevated after an acute Myocardial Infaraction (MI).



Using the graph, match the following:

Column I	Column II
____ Line A indicates	CPK
	LDH
____ Line B indicates	AST (SGOT)
	ALT (SGPT)
____ Line C indicates	

7. The direction of migration of proteins in an electrical field is determined by:

   a. The surface charge of the protein
   b. Ionic strength of buffer
   c. Endosmosis
   d. Size of the protein particle

8. Electrophoresis of serum is most commonly carried out at a buffer pH of:

   a. 7.6
   b. 8.0
   c. 8.6
   d. 9.0

9. A protein at a pH higher than its iso-electric point is:

   a. insoluble
   b. negatively charged
   c. positively charged
   d. zwitterion

10. SITUATION: A patient has a total protein of 9.0 gm/dl. She is found to have abnormal protein - both pryoglobulin and cryoglobulin. Both migrate electrophoretically between beta and gamma globulin. This picture indicates:

    a. Rheumatoid arthritis
    b. Raynaud's syndrome
    c. Lypus erythematosus
    d. Multiple myeloma

11. The accepted method for quantitation of protein is based on the nitrogen content as measured by the method of:

    a. Kjeldahl
    b. Biuret
    c. Berthlot
    d. Nessler

12. An advantage of the Kinetcis methods which measure enzyme activity is that:

    a. substrate depletion is observable
    b. there is elimination of a lag phase
    c. the pH of the system is not critical
    d. less sophisticated instrumentation is needed

13. Zero-order Kinetics results:

    a. when there are equal amounts of enzyme and substrate present.
    b. when there is more substrate than enzyme present.
    c. when all the available sites on the enzyme are saturated with substrate.
    d. when none of the available sites on the enzyme are saturated with substrate.

14. The enzyme most helpful in distingusihing between bone and liver origin of an elevated alkaline phosphatase is:

    a. leucine aminotranspeptidase
    b. creatine kinase
    c. aldolase
    d. lactate dehydrogenase

15. The copper containing enzyme is:

    a. cholinesterase
    b. ceruloplasmin
    c. aldolase
    d. amylase

16. K_m represents:

    a. The overall velocity constant for the enzyme reaction.
    b. The maximum velocity the enzyme reaction can reach.
    c. The velocity attained with zero-order kinetics.
    d. The average velocity for the enzyme reaction.

17. Serum is the specimen of choice for enzyme analysis because:

    a. a high concentration of electrolytes in urine would enhance activity.
    b. whole blood will give lower values due to a difference in water distribution between the cell and fluid.
    c. plasma is cloudy and its use would result in falsely elevated values.
    d. anticoagulants may act as inhibitors.

18. Isoenzymes are:

a. multiple molecular forms of an enzyme.
b. different enzymes which exhibit the same enzyme specificity.
c. multiple molecular forms of different enzymes.
d. different enzymes which exhibit the same electrophoretic mobility.

19. An enzyme whose activity is related to surface area and not substrate concentration is:

a. aldolase
b. amylase
c. ceruloplasmin
d. lipase

20. Enzymes act by:

a. shifting the equilibrium position of a reaction.
b. causing thermodynamically incompatible reactions to occur.
c. increasing the rate of reaction in one direction only.
d. decreasing the amount of free energy of activation necessary.

21. SITUATION: The patient has an elevated creatine kinase, lactic dehydrogenase and aldolase. The AST and ALT are normal. This is indicative of:

a. hepatitis
b. myocardial infarction
c. muscle wasting
d. brain damage

NOTE: The following questions relate to ACID-BASE chemistry. (22-26)

22. The oxygen dissociation curve relates the partial pressure of oxygen (pO_2) to:

a. % saturation of plasma.
b. pCO_2 at normal pH.
c. plasma dissolved oxygen.
d. % saturation of hemoglobin with oxygen.

23. The acid-base status of a patient may be elucidated by knowing the blood pH and the additional information of:

a. blood pO_2
b. respiratory rate
c. Blood pCO_2 and the Henderson-Hasselbach equation.
d. Total CO_2 after blood equilibration with 5% CO_2 gas.

24. In the normal kidney physiology, the ion exchange mechanism provides for a conservation of _____ ion with an increased concentration of hydrogen ion in the urine.

a. potassium
b. ammonium
c. sodium
d. calcium

25. The majority of blood carbon dioxide is carried in the blood as:

    a. bicarbonate
    b. Total CO_2
    c. Carbonic acid
    d. pCO_2

26. The major buffer systems in plasma would NOT include:

    a. $\frac{\text{protein anion}}{\text{protein}}$

    b. $\frac{\text{bicarbonate}}{\text{carbonic acid}}$

    c. $\frac{\text{sodium phosphate}}{\text{phosphoric acid}}$

27. A glycoprotein which migrates electrophoretically with an $alpha_2$ globulin mobility and demonstrates a high affinity for globin protein is known as:

    a. methemalbumin
    b. macroglobulin
    c. $alpha_2$ globulin
    d. haptoglobin

28. The following laboratory results were obtained on Mr. Z:

Total lipids	850 mg/dl
Triglycerides	325 mg/dl
Cholesterol	205 mg/dl
Lipoportein electrophoresis - normal	

    The electrophoresis was done on a separate sample. Give probable explanations.

29. Which of the following lipids would precipitate with digitonin?

    a. triglyceride
    b. phospholipid
    c. free cholesterol
    d. esterified cholesterol
    e. free fatty acid

30. All cholesterol assays have in common:

    a. a transmethylation
    b. the use of ferric chloride
    c. a dehydration
    d. a precipitation
    e. an esterification

Special Chemistry

Quality Control Questions

1. Match the description in Column B with the terms in Column A

Column A	Column B
____ accuracy	a. encompasses 95.45% of all results in a gaussian distribution.
____ precision	b. the deviation expressed as the percentage variance from the mean
____ standard	c. the closeness of the test value to the true mean.
____ control	d. the spread between replicates or variation within the analytical method.
____ standard deviation	e. highly purified material of known composition
____ coefficient of variation	f. the measure of the scatter around the mean in a gaussian distribution
____ 95% confidence	g. an increasing or decreasing gradual deterioration of the test system.
____ systematic shift	h. caused by intrinsic properties of the method due to change
____ systematic trend	i. a change in values caused by a sudden sustained test system failure or bias
____ random error	j. a material whose physical and/or chemical composition more closely resembles the unknown test specimen
	k. the spread between the highest and the lowest measurment in a series
	l. the process of relating a measurement instrument or device to primary physical constants

2. If a laboratory tries to use control sera as a control as well as for a standard, the result is:

   a. an improvement in the accuracy of the test
   b. simply two standards with no control specimen for the detection of test descrepancies
   c. a fulfillment of federal regulations for independent laboratories
   d. an improvement in the precision of the test

3. Which of the following illustrates an out-of-control situation?

   a. six successive plots falling above or below the mean value.
   b. six successive plots falling on the mean value.
   c. two plots in 20 days falling outside the mean $\pm$ 2S.
   d. none of the above.

4. SITUATION: You are using only one control on your daily run for a batch of tests. You have set up your control limits at 95% confidence ($\bar{x}$ + 2S) and you find that your control is high out-of-control falling between +2S and +3S on your chart. Which of the following would NOT be a possible course of action for you to take.

   a. repeat the control only to see if it returns to an in-control situation.
   b. report out the patients' results assuming this is a random error only.
   c. report your results to your supervisor or physician in charge.
   d. repeat the entire rune of tests.

5. SITUATION: You are using two controls on your daily run for a batch of tests. You set up your control limits at 95% confidence ($\bar{x}$ + 2S) and you find that one control falls within limits and the second control is high out-of-control falling between +2S and +3S on your charts. Your most probable course of action would be:

   a. to repeat the control specimen only to see if it returns to an in-control situation.
   b. to report out the patient results.
   c. to repeat the entrie test run including the controls.
   d. a matter of judgement, depending on special circumstances - such as what has occured prior to this on the charts and also the location of the control that was within limits on the control chart.

6. An effective preventive maintenance and calibration program will:

   a. reduce the loss of time due to breakdown
   b. reduce the variation in test results caused by poor instrument performance
   c. extend the life of the instrument
   d. all of the above

7. Daily preventive maintenance and calibration actions defined in the methodology should be performed by:

   a. the electro-mechanical technician
   b. the medical technologist
   c. the laboratory assistant
   d. the pathologist

True or False

____ 8. A clinical laboratory purchasing a new instrument should specify in the purchase order that complete operating and maintenance instructions, including circuit diagrams and schematics of all instrument components, must be supplied.

___ 9. The preventive maintenance and calibration sticker is adequate evidence of preventive maintenance and calibration in the laboratory.

____10. It is a good rule to replace an instrument before the maintenane or overhaul cost exceeds 50 to 65% of the replacement cost on an annual basis.

11. Parts that have a decreasing failure rate with time (i.e., transistors, integrated circuits, capacitors, etc.) should:

   a. only be replaced if they fail
   b. be replaced on a routine preventive maintenance schedule.

Safety Questions

1. When a laboratory worker accidentally gets H_2SO_4 in her eyes, she should immediately use:

   a. water and sodium bicarbonate
   b. water
   c. sodium bicarbonate
   d. saline

2. Which of the following steps should be followed when one is diluting acid?

   a. add the acid slowly to the water while mixing.
   b. one should wear safety glasses.
   c. mixing should be done in a confined area such as a sink.
   d. only a and b
   e. all of the above

3. Match the following chemical agents with the effect each has on the human body.

a. ____ sulfur dioxide	1. carcinogenic
b. ____ carbon tetrachloride	2. contact dermatitis
c. ____ benzidine	3. severe burns to the lungs
d. ____ phenol	4. liver damage
	5. prevents oxygenation of blood

4. The flash point of a chemical is defined as:

   a. the point at which it gives off vapor sufficient to form an ignitible mixture with air.
   b. the point at which there is spontaneous combusion.
   c. a surface temperature equal to its ignition temperature times its specific gravity.
   d. none of the above.

5. Developing standards for occupational safety is the primary responsibility of the:

   a. National Institute for Occupational Safety and Health.
   b. Occupational Safety and Health Administration.
   c. National Institute of Health.
   d. Institute for Safety Supervision and Training.

6. Which of the following would <u>NOT</u> be an appropriate safeguard in the handling of flammable liquids?

   a. isolation of the hazard
   b. confinement of the liquid
   c. elimination of possible vent sites
   d. elimination of ignition sources

7. Aerosols can be produced by:

   a. popping open blood containers
   b. pouring off a serum sample
   c. centrifuging open serum tubes
   d. all of the above

8. The primary problem presented by the presence of copper azides in plumbing is that they may be

   a. toxic
   b. corrosive
   c. explosive
   d. odoriferous

9. Recommended as the best means for decontamination of materials suspected of harboring the hepatitis antigen is

   a. bleach
   b. soap and water solution
   c. acid
   d. caustic substance

10. Pouring flammable liquids from one container to another presents fire hazards. The most common fire hazard is the possiblity of

   a. explosion caused by static spark
   b. spontaneous combustion
   c. fire caused by heat of friction
   d. the liquid vaporizing and leaving an explosive pocket

Toxicology

Subject: Anticonvulsants
Volatiles (alcohols)
Barbiturates
Tranquilizers
Drug Screen Confirmations
Lithium
Lead
Wet bench (propanolol, quinidines, bromides, salicylates and carbon monoxide).
Qualitative drug screens

Instrumentation: Spectrophotometer
Gas Chromatograph
Atomic Absorption
Fluorometer
Anodic Strigging Voltometry (ASV)
Emit System

Pre-requisite Skills:

1. Explain the normal and abnormal physiology, related to each of the test results.
2. Discuss the following components of the test procedure:
    a. Principle
    b. Procedure
    c. Specimen collection
3. Interpret the results of each test procedure in terms of:
    a. normal and abnormal results
    b. relation to physiology
    c. interrelationship with other laboratory data
4. Discuss the theory of operation of the instruments used in the Toxicology laboratory, with the exception of ASV, including:
    a. the physical principles involved in operation.
    b. the chemical principles involved in operation.

5. List and explain the operation of the essential components of the instruments used in toxicology with the exception of ASV.
6. Describe the mechanism of operation of each instrument with the exception of ASV.

The pre-requisite skills are acquired through independent reading (laboratory manual, reading references) and through a review of lecture materials.

Behavioral Objectives:

Upon satisfactory completion of the Toxicology rotation, the student will be able to:

1. State the principle of each Toxicology procedure
2. Describe the procedures for specimen collection.
3. Determine appropriate methods for specific test procedures.
4. Set up each analytical system performed in Toxicology.
5. Perform the test analysis assigned by the teaching supervisor, according to prescribed methodology.
6. Obtain analytical data and convert, where applicable, to test results.
7. Evaluate the validity of data in relation to the test system.
8. Correlate the test results with other patient data.
9. Determine if additional analysis are needed for clarification of test results.
10. Report results through appropriate systems conforming to established procedures.
11. Identify special precautions and sources of error for each of the procedures. Describe troubleshooting mechanism, when appropriate.
12. Describe the use of the instruments involved in the test procedures.

Learning Experiences:

____ 1. All students are responsible to know the principle of each toxicology procedure listed under SUBJECT on page 1. Record principles in notebook.

____2. For each of the procedures in the Toxicology laboratory, describe the procedure for specimen collection including:

a. time of collection
b. status of the patient
c. handling of the specimen

cont'd on next page

d. medico-legal requirements, where applicable

e. deterioration of constitutents over time, temperature, and light restriction

Record this information in your notebook in table form.

____ 3. For the procedure for lithium analysis by atomic absorption, evaluate the quality of the reagents and diluents used, including the purity of H_2O, the grade of chemicals, and the potency of biologicals.

Record in notebook.

____4. For all the tests listed under SUBJECT, read the test procedures in the designated laboratory manual.

____5. For each test procedure listed under SUBJECT, select and organize at least 2 samples, controls, and reagents according to the specifications of the assay.

____6. Record the results for all test procedures, including controls, in the same manner as these results are listed on the data sheets.

____7. Review the values obtained for your standards and/or controls for their acceptability. For any standards and/or controls that are out of range, record your course of action.

____8. For each of the procedures listed under SUBJECT, state in table form the protocol for reporting results, including:

1. the established system for reporting routine and emergency tests.
2. the parameters which dictate immediate notification.

Record in student notebook.

(ex.) Test	Result Abnormal	Result Normal	Reporting Method
X			Immediate notification, telephone call.
X			Written report within 24 hours.
Y			Immediate notification.

____9. During the Toxicology rotation, make written notes on all special precautions and possible sources of error (including instrumentation) for each of the procedures, and the course of action for correcting each of the errors (troubleshooting).

___10. Answer the attached study questions.

Reading References

1. Clinical Diagnosis and Management by Laboratory Methods - John Bernard Henry, M.D. (16th edition).
   Chapter 15 - Therapeutic Drug Monitoring and Toxicology.
2. Fundamentals of Clinical Chemistry - Norbert Tietz

pp.	88-900	Lithium Analysis
	1100-1104	Introduction and Carbon Monoxide
	1109-1110	Volatiles and principle of alcohol determinations
	1114-1115	Principle of Methanol determination
	1119-1123	Metals-Arsenic and Lead
	1132	Principle of urine screening for drugs
	1138-1139	Barbiturates

3. Elementary Principles of Laboratory Instruments - Leslie Lee

pp.	110-116	Atomic Absorption Photometry
	117-127	Fluorometry
	162-166	Gas Chromatography

Study Questions

1. Thin layer chromatography (TLC) is to R_f as gas liquid chromatography (GLC) is to:

   a. flame ionization
   b. isothermal technique
   c. partition
   d. retention time

2. An R_f value of 0.5 means:

   a. solute moves twice as far as the solvent front.
   b. solvent moves half the distance of the solute.
   c. solute moves half the distance of the solvent.
   d. solute moves with the solvent front.

3. Ninhydrin is sprayed on thin layer plates for visulization of:

   a. amphetamines
   b. barbiturates
   c. sulfonamides
   d. glutethimides (doriden)

4. In gas liquid chromatography, it is necessary for the sample to be:

   a. ionized
   b. volatilized
   c. precipitated
   d. acidified

5. Atomic Absorption Spectrophotometry is based on the fact that atoms of elements in the ground or unexcited state:

   a. emit light of the same wavelength emitted by the element in the excited state.
   b. absorb light at a different wavelength than that emitted by the element in the excited state.
   c. emit light at a different wavelength than that emitted by the element in the excited state.
   d. absorb light of the same wavelength emitted by the element in the excited state.

6. In analyzing durg concentration in blood, the value you obtain is a reflection of:

   a. total drug
   b. bound durg
   c. free drug

7. The most common method for the screening of drugs is:

   a. GLC
   b. Emit
   c. TLC
   d. RIA

8. The packing of a column in GLC consists of:

   a. inert material
   b. stationary phase
   c. mobile phase
   d. a & b
   e. a & c

9. The distance a drug travels up a TLC plate is called its:

   a. R_f
   b. solvent front
   c. retention time
   d. mobility

10. The analytical measurement in Emit is the result of:

   a. reaction of antibody and buffer
   b. reaction of enzyme-labeled drug and substrate
   c. reaction of antibody and substrate
   d. reaction of patient drug and substrate

11. The ultraviolet spectrum covers the wavelength range of:

   a. 150-280 nm
   b. 200-380 nm
   c. 380-700 nm
   d. 700-900 nm

12. In a single-beam, UV instrument, the amount of light passing through the sample is:

   a. 25%
   b. 50%
   c. 75%
   d. 100%

13. The most common and useful light source of UV radiation in an instrument is:

   a. tungsten
   b. tungsten-iodide
   c. deurterium

14. The light source of fluorescence is usually:

   a. Fluorescent light bulb
   b. Tungsten lamp
   c. Xenon source
   d. X-ray source

15. Why are fluorometers designed so that the secondary monochromator and the detector are at right angles to the incident beam?

16. In a fluourmetric procedure, a standard solution containing 20 ug/ml of a known substrate gives a reading of 80 fluorescent units while a 30 ug/ml standard gives a reading of 75 fluorescent units. The standrads are known to be accurate. Give an explanation for this.

17. If a drug appears in durg screen, what follow-up procedure is performed.

18. In reference to GLC analysis, what is the significance of retention time and what are the controlling factors?

19. Explain how thermoconductivity and flame ionization detectors operate.

Case History

A patient was admitted to the hospital with stomach pains. History revealed that the patient was a cocaine abuser and had recently taken cocaine. The urine was negative for cocaine. Why?

Endocrinology

SUBJECT: Vanilmandelic acid
17-Ketogenic Steroids
17-Hydroxycorticosteroids
17-Keto-Steroids
Catecholamines

INSTRUMENTATION: Spectrophotometer
Fluorometer

PRE-REQUISITE SKILLS:

1. Explain the normal and abnormal physiology related to each of the test results.
2. Discuss the following components of the test procedure:
   A. Principle
   B. Procedure
   C. Specimen Collection
3. Interpret the results of each test procedure in terms of:
   A. Normal and abnormal results
   B. Relation to physiology
   C. Interrelationship with other laboratory data
4. Discuss the theory of operation of the instrumentation (spectrophotometer, fluorometer) used in the Endocrinology laboratory including:
   A. The physical principles involved in operation
   B. The chemical principles involved in operation
5. List and explain the operation of the essential components of the spectrophotometer and fluorometer.
6. Describe the mechanism of operation of the spectrophotometer and fluorometer.

The pre-requisite skills are acquired through independent readings (laboratory manual, reading references) and through a review of lecture material.

Behavioral Objectives:

Upon satisfactory completion of the Endocrinology rotation, the student will be able to:

1. State the principle for each Endocrinology procedure listed under subject.
2. Determine appropriate methods for specific test procedure.
3. Set up each analytical system performed in Endocrinology.
4. Perform each test analysis according to prescribed methodology.
5. Obtain analytical data and convert to test results.
6. Evaluate the validity of data in relation to the test system.
7. Interpret results in light of metabolic pathways of analytes (exogenous and endogenous).
8. Correlate the test results with other patient data.
9. Report results through appropriate systems conforming to established procedures.
10. Identify special precautions and sources of error for each of the procedures. Describe troubleshooting mechanism, when appropriate.

Learning Experiences:

____ 1. All students are responsible to know the principle of each Endocrinology procedure listed under SUBJECT on page 1. Principles should be recorded in notebook.

____ 2. For each of the procedures in the Endocrinology laboratory, describe the procedure for specimen collection including:
   a. time of collection
   b. status of the patient
   c. handling of the specimen
   d. medico-legal requirements, where applicable
   e. deterioration of constituents over time, temperature, and light restriction.

   Record this information in your notebook in table form.

____ 3. For the procedure for catecholamines, evaluate the quality of the reagents and diluents used, including the purity of H_2O, the grade of chemicals, and the potency of biologicals.
   Record in notebook.

____ 4. For all the tests listed under SUBJECT, read the test procedures in the designated laboratory manual.

____ 5. For each test procedure listed under SUBJECT, select and organize at least 2 samples, controls, and reagents according to the specifications of the assay.

____ 6. Record the results for all test procedures, including controls, in the same manner as these results are listed on data sheets.

____ 7. Review the values obtained for your standards and/or controls for their acceptability. For any standards and/or controls that are out of range, record your course of action.

____ 8. For each of the procedures listed under SUBJECT, state in table form the protocol for reporting results, including:

1. the established system for reporting routine and emergency tests.
2. the parameters which dictate immediate notification.

Record in student notebook.

(ex.) Test	Results Abnormal	Results Normal	Reporting Method
X			Immediate notification, telephone call
X			Written report within 24 hours
Y			Immediate notification

____ 9. During the Endocrinology rotation, make written notes on all special precautions and possible sources of error (including insqrumentation) for each of the procedures, and the course of action for correcting each of the errors, (troubleshooting).

___10. Answer the attached study questions, and quality control questions. Record in student notebook.

___11. Solve the attached math problems. Record all work in student notebook and <u>circle the final answer</u>.

Reading References:

Fundamentals of Clinical Chemistry - Norman Tietz

Chapter 13 - Endocrine Function

Clinical Diagnosis and Management by Laboratory Methods -
John Bernard Henry M.D.

Chapter 14 - Evaluation of Endocrine Function

Elementary Principles of Laboratory Instruments - Leslie Lee

Chapter 4 - Spectrophotometry

6 - Fluorescence and fluormetry

Math problems

1. Express 5.7 meq/l of potassium as mg/dl. Molecular weight potassium - 39.1 gm.

2. What is the concentration of 250 ml of 0.85% saline in terms of molarity and normality? Molecular weight NaCl = 58.5 gm.

3. A chemistry procedure calls for a 7 gm/dl anhydrous sodium acetate solution. You only have $NaOOCCH_3 \cdot 3H_2O$. How much of the hydrated form is need to prepare 150 ml of 7 gm/dl $NaOOCCH_3$? Molecular weight $NaOOCCH_3 \cdot 3H_2O$ = 136 gm.

4. What is the pH of $10^{-4}M$ H_2SO_4?

5. The following is a list of results of 20 replicate glucose assays. Calculate the mean, median, mode, standard deviation and coefficient of variation.

Concentration of glucose in mg/dl

96
98
98
95
97
99
100
100
97
96
95
97
94
98
97
99
100
97
96
98

Study Questions

1. Urinary catecholamines originate from the:

   a. pituitary gland
   b. thyroid gland
   c. gonads
   d. adrenal glands

2. A patient has elevated urine levels of both 17-ketogenic steroids and 17-hydroxycorticosteroids. Which endocrine tissue is implicated?

   a. adrenal medulla
   b. adrenal cortex
   c. thymus
   d. parathyroid

3. Matching

   ____ Porter-Silber Reaction

   ____ Zimmerman Reaction

   a. 17-hydroxycorticosteroids
   b. VMA
   c. Metanephrines
   d. Total estrogens
   e. 17-ketosteroids

4. List the four general steps in the assay procedures (excluding RIA) for steroid hormones.

   a.

   b.

   c.

   d.

5. Catecholamines are amines which are distinguished by the presence of two hydroxyl groups on a benzene ring. What are the three most important endogenously produced compounds of this group and what is the primary excretion product of each?

   a.

   b.

   c.

6. Forty laboratory personnel considered normal were used in a study to establish normal limits for a new VMA procedure. Thirty-eight of the subjects fell within established published limits of 1.8 to 7.1 mg/24 hrs. Two of the people had extremely elevated levels. What is a possible explanation.

7. A. ACTH stimulation tests are most helpful in distinguishing between what two conditions?

   1.

   2.

   B. What would be the pattern of urinary corticosteroids excretion expected of each condition in response to ACTH?

8. VMA is the major metabolite of:

   a. epinephrine and norepinephrine
   b. catecholamines
   c. metanephrines
   d. none of the above

9. 17 ketosteroids are metabolites of:

   a. gonadotropic hormones
   b. pituitary hormones
   c. adrenal medullary hormones
   d. adrenal cortex hormones

10. Case History

The following lab results were reported on a patient:

Serum:	Ca# -	normal
	Phosphorus -	normal
	Alkaline phosphatase -	normal
	Glucose	increased
	T_4-	normal
Urine:	Ca# -	normal
	glucose-	normal
	17-ketogenicsteroids -	increased
	17-ketosteroids -	increased
	gonadotropins -	normal
Whole Blood:	RBC's -	increased with normal morphology
	WBC's -	increased with normal morphology
	Platelets -	normal

These results most probably indicate:

a. Addisons' disease
b. Cushings' syndrome
c. Gouchers' disease
d. Hypoparathyroidism

Quality Control Questions

1. Unassayed control materials are considered cheaper than assayed control materials and essentially contain the same constituents. If you choose to use unassayed materials in your control system, which of the following things must be done before the unassyed control material is run through the procedure to establish a 95% confidence limit or action limits?

   a. send the material to other laboratories for them to assay it for you.
   b. adjust the control ranges so that the procedure produces control values between the mean $\pm$ 2S.
   c. the accuracy and precision of the methodology should be verified and procedure must be in-control when the unassayed material is tested.
   d. check with the manufacturer to see what type of reproducibility you should get.

2. When establishing a mean $\pm$ 2S range for an unassayed control that is to be used subsequently as a daily control, the method of choice for collecting replicate measurements is to:

   a. run 20 to 30 replicates on the same day on the same run.
   b. run 20 to 30 replicates over a period of 20 to 30 days.
   c. run 20 to 30 replicates on the same day on more than one run.
   d. run duplicates on each daily run and average results for 20 to 30 days.

3. You wish to determine the effect of an interfering material on the measurement of a given constituent. The type of error that is measured by this study is:

   a. a wild error
   b. a random error
   c. a systematic constant error
   d. a systematic proportional error

4. An error that is always in one direction and has the same magnitude regardless of the concentration is a:

   a. wild error
   b. random error
   c. systematic constant error
   d. systematic proportional error

5. An error that is always in one direction and fixed in terms of percent is a:

   a. wild error
   b. random error
   c. systematic constant error
   d. systematic proportional error